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EFFECTS OF REINFORCER CONSUMPTION AND MAGNITUDE ON RESPONSE RATES DURING NONCONTINGENT REINFORCEMENT

EILEEN M. ROSCOE

NEW ENGLAND CENTER FOR CHILDREN

AND

BRIAN A. IWATA AND MELISSA S. RAND

UNIVERSITY OF FLORIDA

Results of previous research on the effects of noncontingent reinforcement (NCR) have been inconsistent when magnitude of reinforcement was manipulated. We attempted to clarify the influence of NCR magnitude by including additional controls. In Study 1, we examined the effects of reinforcer consumption time by comparing the same magnitude of NCR when session time was and was not corrected to account for reinforcer consumption. Lower response rates were observed when session time was not corrected, indicating that reinforcer consumption can suppress response rates. In Study 2, we first selected varying reinforcer magnitudes (small, medium, and large) on the basis of corrected response rates observed during a contingent reinforcement condition and then compared the effects of these magnitudes during NCR. One participant exhibited lower response rates when large-magnitude reinforcers were delivered; the other ceased responding altogether even when small-magnitude reinforcers were delivered. We also compared the effects of the same NCR magnitude (medium) during 10-min and 30-min sessions. Lower response rates were observed during 30-min sessions, indicating that the number of reinforcers consumed across a session can have the same effect as the number consumed per reinforcer delivery. These findings indicate that, even when response rate is corrected to account for reinforcer consumption, larger magnitudes of NCR (defined on either a per-delivery or per-session basis) result in lower response rates than do smaller magnitudes.

DESCRIPTORS: noncontingent reinforcement, reinforcer magnitude, satiation

Noncontingent reinforcement (NCR), the delivery of reinforcers according to a response-independent schedule, has been shown to be an effective treatment for a wide range of problem behaviors (Carr et al., 2000). Because most early applications of NCR involved concurrent implementation of extinction (e.g., Hagopian, Fisher, & Legacy, 1994; Vollmer, Iwata, Zarcone, Smith, & Mazaleski, 1993), it was not clear if decreases in problem behavior were the result of satiation or extinction. Several recent studies have shown behavior reduction during NCR in the absence of extinction, suggesting that reinforcer delivery per se may reduce behavior through satiation (Fischer, Iwata, & Mazaleski, 1997; Lalli, Casey, & Kates, 1997). Additional research has attempted to identify the relative contributions of satiation and extinction during NCR (Hagopian, Crockett, van Stone, DeLeon, & Bowman, 2000; Kahng, Iwata, Thompson, & Hanley, 2000). These studies were conducted in a clinical context and required complex methodology that was secondary to the evaluation of treatment effects. For this reason, nonclinical studies also may be helpful in identifying subtle influences on behavior through parametric or component analyses, which may be difficult to undertake in a clinical context.

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Reprints may be obtained from Brian Iwata, Psychology Department, University of Florida, Gainesville, Florida 32611.

Carr, Bailey, Ecott, Lucker, and Weil (1998) conducted a nonclinical analysis by examining the effects of reinforcer magnitude during NCR. They first established baseline rates of responding during a contingent reinforcement (CR) condition, in which a small amount of a preferred edible item was delivered for the occurrence of arbitrary responses on variable-ratio (VR) schedules. They then exposed participants to two or three NCR conditions in multielement designs that differed with respect to reinforcer magnitude (small, medium, and large). The medium-magnitude reinforcer (e.g., one cookie) was three times larger than the small-magnitude reinforcer (one third of a cookie), and the large-magnitude reinforcer (e.g., two cookies) was six times larger than the small-magnitude reinforcer. Results generally showed an inverse relation between reinforcer magnitude and response rate: Larger magnitudes of reinforcement were associated with lower response rates. These findings suggested that large reinforcer magnitudes produce satiation more readily than do small ones, thereby enhancing the therapeutic effects of NCR.

Ecott, Foate, Taylor, and Critchfield (1999) attempted to replicate the findings of Carr et al. (1998). One procedural difference was that Ecott et al. compared only two reinforcer magnitudes. The large-magnitude reinforcer was either three or four times larger than the small-magnitude reinforcer; thus, the proportional difference between small and large in the Ecott et al. study was more similar to that between small and medium in the Carr et al. study. A second difference was that the effects of reinforcer magnitude were examined during both CR and NCR conditions. During CR conditions, response rates were similar when small- and large-magnitude reinforcers were delivered. During NCR conditions, responding decreased when small- and large-magnitude reinforcers were delivered, but no differences were observed as a function of reinforcer magnitude. Thus, results of the Ecott et al. study, unlike those of Carr et al., suggested that reinforcer magnitude did not differentially affect response rates during NCR.

A potential limitation of both studies was that response rates were based on total session time. Because reinforcer consumption may occupy a larger proportion of the session as reinforcer magnitude increases, differences in response rates during small- and large-magnitude conditions (i.e., lower rates during large-magnitude conditions) in the Carr et al. (1998) study may have reflected differences in reinforcer consumption time, as suggested by data for 1 participant in a recent study by Wilder, Fisher, Anders, Cercone, and Neidert (2001).

Another limitation of these NCR magnitude studies that may have accounted for the discrepant findings was that reinforcer magnitude was defined arbitrarily, independent of its effects on behavior. Thus, it is possible that the difference between small- and large-magnitude reinforcers was a functional one for participants in the Carr et al. (1998) study but not for participants in the Ecott et al. (1999) and Wilder et al. (2001) studies. Although Carr et al. and Wilder et al. did not compare small- and large-magnitude reinforcers during CR conditions, Ecott et al. did and observed similar rates of responding. Given that the specific reinforcer magnitudes selected by Ecott et al. had no differential effects on response rates during the CR condition, it is not surprising that similar results were observed during the NCR condition. Perhaps a larger difference between the small- and large-magnitude reinforcers would have affected response rates during both the CR and the NCR conditions in the Ecott et al. study as well as during the NCR conditions in the Wilder et al. study.

In the present studies, we examined the influence of reinforcer magnitude during

NCR and incorporated two types of controls, one for reinforcer consumption and another for reinforcer magnitude. Two reinforcer magnitudes (small and medium) were compared in Study 1, and the larger magnitude was conducted under two different conditions: one in which reinforcer access time was subtracted from overall session time and one in which it was not. This procedure permitted an examination of the effects of reinforcer consumption independent of magnitude. Three reinforcer magnitudes (small, medium, and large) were compared in Study 2, in which session length was equated to account for reinforcer access time. However, prior to examining magnitude effects during NCR, probe trials were conducted during a CR condition to identify reinforcer magnitudes that resulted in decreases in responding (i.e., functional differences in magnitude).

GENERAL METHOD

Participants, Setting, and Sessions

Four individuals (Calvin, Brett, Noreen, and Daniel), ranging in age from 23 to 39 years, participated. Calvin and Brett participated in Study 1; Noreen and Daniel participated in Study 2. All had been diagnosed with severe to profound mental retardation but could follow simple instructions and emit the target response (see below) with minimal prompting. Experimental sessions were conducted at a workshop facility for persons with developmental disabilities. One to four sessions were conducted each day with each participant and were scheduled at the same time of day for a given participant (approximately 2 hr following a meal) to minimize external sources of food satiation or deprivation. During Study 1, no more than two sessions were conducted on a given day during the NCR condition; during Study 2, only one session was conducted each day during both the CR and the NCR conditions.

Stimulus Preference Assessment

Assessments were conducted with each participant to identify highly preferred edible items. A multiple-stimulus format, based on procedures described by DeLeon and Iwata (1996), was used for Calvin, Noreen, and Daniel. During each session, seven food items were presented simultaneously during the first trial. The participant was instructed to select one item and was allowed to consume the item selected. Subsequent trials contained the remaining food items; that is, items selected during previous trials were not replaced. This procedure continued until all items were selected or until no selection was made within 30 s from the beginning of the trial. The entire procedure was repeated five times. A paired-stimulus assessment, based on procedures described by Fisher et al. (1992), was used for Brett. During each trial, two of the seven food items were presented, and Brett was instructed to select one. If Brett selected either item within 5 s, he was allowed to consume it while the other item was removed. If no selection occurred, he was prompted to sample both items, and the trial was repeated. This sequence continued until each item had been paired with every other item.

Following completion of the assessments, the stimuli were ranked according to the percentage of trials on which each item was selected, and the food item ranked highest was used during subsequent reinforcement conditions. The specific stimuli and the percentage of trials on which they were selected were as follows: Calvin (Cheez-it®, 45.5%), Brett (peanut butter M&Ms®, 100%), Noreen (Fritos®, 41.7%), and Daniel (Fritos, 71.4%).

Two observers independently recorded participants' selections on every trial of the assessment, and interobserver agreement was calculated by dividing the number of agreements on item selection by the number of agreements plus disagreements and multiplying by 100%. Mean agreement percentages were 100% for Calvin, 95.2% for Brett, 100% for Noreen, and 100% for Daniel.

Response Measurement and Interobserver Agreement

Target responses were simple motor responses that could be easily shaped. Calvin's response was raising his hand, defined as an upward motion of the hand until his fingertips were above the top of his head (his hand had to descend below shoulder level before another response could be scored). Brett's response was pressing a mechanical switch with enough force to make a clicking sound. Noreen's and Daniel's response was the manual sign for "more," defined as bringing the fingertips of both hands together and then moving them outward at least 1 in.

Observers recorded the frequency of target responses and reinforcer deliveries on laptop computers. Target responses that occurred during reinforcer access time were scored on a different key than were target responses that occurred when the reinforcer was unavailable. Reinforcer access time began each time the experimenter placed reinforcers on a plate and ended when the participant placed the last food item in his or her mouth. Total session time was recorded by the computers used for data recording, and reinforcer access time was recorded on a separate timer. During sessions in which session time was corrected to account for reinforcer access time (see below), responding that occurred during reinforcer access time was not counted when calculating response rates.

A second observer collected data independently during 44.4%, 33.3%, 45.5%, and 37.3% of the sessions for Calvin, Brett, Noreen, and Daniel, respectively. In comparing observers' records, agreement percentages were calculated by first dividing session time into 10-s intervals. The smaller number of recorded responses in each interval was divided by the larger number; these fractions were averaged across the session and multiplied by 100% to yield the percentage agreement between the two observers. Mean interobserver agreement for the target response was 87.2% (range, 70.4% to 100%) for Calvin, 81.8% (range, 57.9% to 100%) for Brett, 96.1% (range, 77.1% to 100%) for Noreen, and 97.6% (range, 85.6% to 100%) for Daniel. Mean interobserver agreement for reinforcer delivery was 87.3% (range, 58.6% to 100%) for Charles, 87.3% (range, 42.4% to 100%) for Brett, 95.6% (range, 87.5% to 100%) for Noreen, and 98.3% (range, 90% to 100%) for Daniel.

STUDY 1

Carr et al. (1998) observed lower response rates during medium- and large-magnitude NCR conditions relative to the small-magnitude condition, suggesting that reinforcer magnitude affects response rates during NCR. However, because reinforcer access time was included in the session time when data were calculated, the extent to which response rates were differentially affected by the amount of time spent consuming reinforcers was unknown. In other words, it is possible that lower response rates under the medium- and large-magnitude conditions simply reflected more time consuming larger quantities of reinforcement but were not indicative of actual response rates between reinforcer deliveries.

In this study, we compared rates of responding during a small-magnitude CR condition with those observed during three NCR conditions. One condition, the small-magnitude NCR condition, provided a comparison for the removal of the contingency. Session time was not corrected during the small-magnitude NCR condition for two reasons. First, we wanted to replicate closely the Carr et al. (1998) procedures except for the magnitude we were manipulating. Second, Carr et al. did not observe decreases in responding during the small-magnitude NCR condition relative to a small-magnitude CR condition, indicating that reinforcer consumption per se exerted little influence over responding when small quantities of reinforcement were delivered. To assess the effects of reinforcer access time, we also examined responding under two medium-magnitude NCR conditions, one of which was corrected to account for reinforcer access time.

Procedure

Baseline (no reinforcement), contingent reinforcement (CR), and noncontingent reinforcement (NCR) conditions were presented sequentially, and the effects of the latter two conditions were evaluated in multiple baseline (both participants) and reversal (Brett only) designs. During the NCR condition, three reinforcer magnitudes—small, medium (uncorrected), and medium (corrected)—were alternated in a multielement design.

All sessions were 10 min in duration, and all sessions for a given participant were conducted by the same experimenter (graduate or undergraduate research assistant). To facilitate discrimination of the conditions in effect during a given session, the experimenter prompted the participant to emit the number of responses required for reinforcement, or to experience the delivery of reinforcers in the absence of responding, twice at the beginning of each session.

Baseline (no reinforcement). This condition was implemented to determine the rate at which target responses occurred when reinforcers were unavailable. No food was delivered during these sessions.

Contingent reinforcement (CR). This condition established the rate of responding when CR was delivered and was used as the basis for determining whether response rates decreased during NCR. During CR sessions, the small-magnitude reinforcer (one piece of the participant's most preferred edible item) was delivered initially on a fixed-ratio (FR) 1 schedule and subsequently was thinned to an FR 2 schedule and then to a VR 3 schedule. Reinforcer delivery during this and all subsequent conditions involved the experimenter placing the item on a plate that was located on the table in front of the participant.

Noncontingent reinforcement (NCR). During these sessions, reinforcers were delivered on a fixed-time (FT) schedule that matched the mean rate of reinforcer delivery during VR 3 sessions from the CR condition. Calvin's NCR schedule was FT 10 s; Brett's NCR schedule was FT 8 s. The effects of three reinforcer magnitudes were compared. During small-magnitude sessions, one piece of the participant's most preferred edible item was delivered according to the designated FT schedule. Reinforcer consumption time (the amount of time elapsed from placement of the food on the plate to consumption) was not subtracted from the total session time. Thus, small-magnitude NCR sessions were identical to CR sessions except for the absence of the contingency. During medium-magnitude sessions, three pieces of the participant's most preferred edible item were delivered. The determination of "medium" was based on the Carr et al. (1998) procedures, in which the medium-magnitude reinforcer was three times as large as the small-magnitude reinforcer. Two types of medium-magnitude sessions were conducted. During medium-magnitude (uncorrected) sessions, reinforcer consumption time was not subtracted from the total session time. During medium-magnitude (corrected) sessions, reinforcer consumption time was subtracted from total session time. That is, response rates were based solely on the

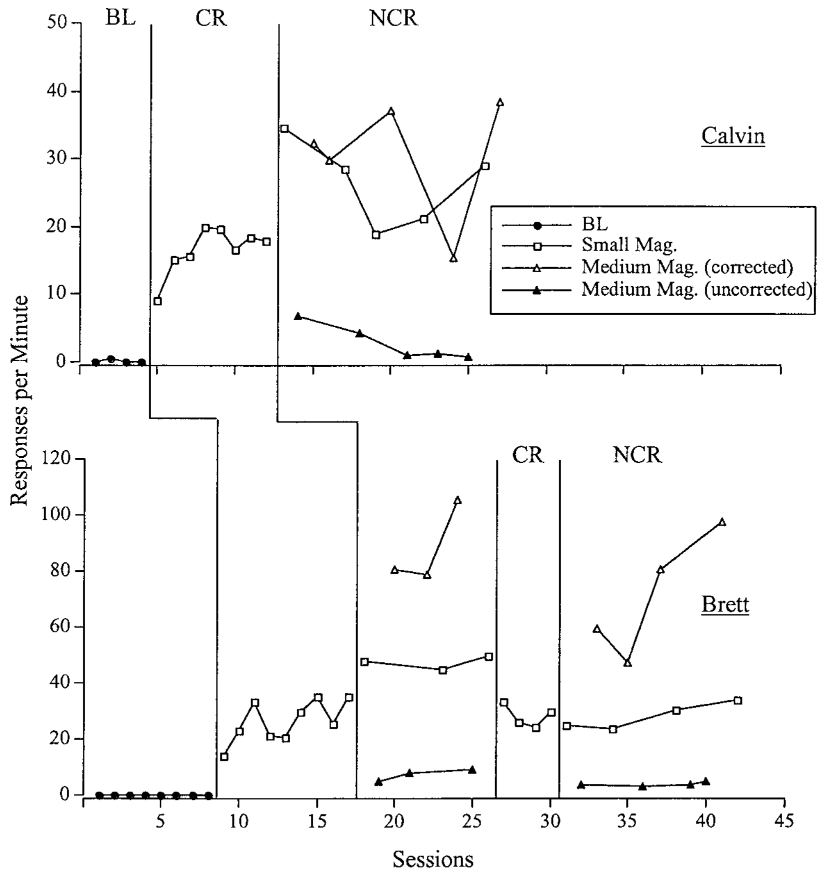

Figure 1. Responses per minute exhibited by Calvin and Brett during no-reinforcement (baseline), contingent reinforcement (CR), and noncontingent reinforcement (NCR) conditions.

amount of session time during which reinforcers were unavailable. This correction procedure was based on conventions described by Lattal (1991) and Mazur (1983) for calculating response rates in basic research. The schedule of reinforcer delivery during corrected sessions was thinner than that used during uncorrected sessions because the FT schedule was paused during reinforcer consumption for the corrected sessions, whereas the FT schedule continued during reinforcer consumption for uncorrected sessions.

Results and Discussion

Figure 1 shows rates of arm raising (Calvin) and switch pressing (Brett) during baseline, CR, and NCR conditions. During baseline sessions, Calvin's mean rate of arm raising was 0.1 responses per minute; Brett's switch pressing never occurred. During the CR condition, Calvin's and Brett's responding increased to 18.1 and 28.6 responses per minute, respectively. During the small-magnitude NCR condition, Calvin's and Brett's response rates increased above those observed in the CR condition and averaged 26.4 and 47.4, respectively. During the medium-magnitude (uncorrected) NCR condition, both participants' response rates (mean of 2.8 for Calvin and 7.1 for Brett) showed substantial decreases relative to the CR and small-magnitude NCR conditions. However, when session time was corrected to account for reinforcer consumption in the medium-magnitude (corrected) NCR condition, Calvin responded at a rate (30.6) similar to that observed in the small-magnitude NCR condition, and Brett responded at a rate (88.2) higher than that observed in any other condition. Brett's switch pressing during his second exposure to CR occurred at about the same rate (28.1) as during his first exposure. Finally, Brett's second exposure to the NCR conditions produced response rates similar to those observed during his first exposure: 28.1 during small-magnitude NCR, 3.7 during medium-magnitude (uncorrected) NCR, and 71.2 during medium-magnitude (corrected) NCR.

The present findings replicated those reported by Carr et al. (1998) in that (a) no decreases in responding were observed when CR and NCR were compared under small-magnitude conditions, and (b) much lower rates of responding were observed during a medium-magnitude NCR condition. However, the medium-magnitude NCR condition in the Carr et al. study was similar to the medium-magnitude (uncorrected) NCR condition in the present study. In both conditions, the amount of time spent consuming reinforcers was included in the calculation of response rates. We also included a medium-magnitude (corrected) NCR condition, in which session time was adjusted to account for consumption of larger quantities of reinforcers. During this condition, response rates did not decrease but actually increased. These results suggest that lower response rates observed during the medium-magnitude NCR condition in the Carr et al. study may have been due to reinforcer consumption. That is, when a larger quantity of reinforcers is delivered, more time is spent consuming them; as a result, overall response rates are suppressed.

Although the present results indicated that reinforcer consumption can affect rate of responding under certain conditions, they did not adequately answer the question of whether reinforcer magnitude per se affects response rates (given an adjustment for consumption) because only two quantities of reinforcement were compared—small (one item) and medium (three items)—and the difference between them was similar to that in the Ecott et al. (1999) study, in which magnitude had no apparent influence on responding. It is possible that a larger difference in reinforcer magnitude would affect responding, and this was examined in Study 2.

STUDY 2

Results of the Carr et al. (1998) and Ecott et al. (1999) studies showed discrepant findings with respect to the influence of reinforcer magnitude on responding during NCR. As noted previously, however, reinforcer magnitudes differed noticeably across the studies and were selected arbitrarily. In determining whether two (or more) reinforcer magnitudes differentially affect responding during NCR, a functional difference in magnitude should first be established. That is, if large magnitudes of reinforcement decrease responding through satiation, these effects should be evident during a CR condition. To this end, the purpose of Study 2 was to examine reinforcer-magnitude effects during NCR using magnitudes that were selected based on whether they affected behavior during CR. In addition, because the effects of a given reinforcer magnitude may vary depending on the total amount of reinforcement consumed in a session (i.e., session length), we compared the effects of the same reinforcer magnitude during brief (10-min) and long (30-min) sessions. Finally, based on results from Study 1, session length was adjusted to account for reinforcer consumption time.

Procedure

The general procedures used for conducting sessions were the same as those in Study 1, except as noted below. Baseline (no reinforcement), CR probe, CR, and NCR conditions were presented sequentially, and the effects of CR and NCR were assessed in multiple baseline and reversal designs. Within the CR and NCR conditions, three types of sessions that differed with respect to reinforcer magnitude (small, medium, and large) were alternated in a multielement design. Given the large magnitudes of reinforcement that were delivered during some conditions, subtracting reinforcer consumption time from a constant 10-min session (as was done in Study 1) may have resulted in very brief session durations. Therefore, session length in Study 2 was equated by stopping the timer during reinforcer consumption, so that all sessions lasted for 10 min during which reinforcers were unavailable.

Baseline (no reinforcement). This condition was identical to the no-reinforcement baseline in Study 1.

Contingent reinforcement (CR probes). The purpose of this condition was to establish functional differences in reinforcer magnitude. As in Study 1, an FR 1 schedule of reinforcement was used to establish responding and was then thinned to an FR 2 and then a VR 3 schedule. When relatively stable rates of responding were observed during VR 3 sessions, reinforcer magnitude was doubled across sessions until responding decreased to below 70% of its mean rate during the initial VR 3 sessions. For example, the first increase in magnitude involved delivery of a reinforcer that was twice as large (e.g., two equal-sized pieces of Frito) as the small-magnitude reinforcer (one piece of Frito) following an average of three responses. If response rate did not decrease during the session (indicating satiation), reinforcer magnitude was doubled again (four pieces of Frito) during the subsequent CR session. This procedure continued until we identified a reinforcer magnitude that resulted in decreased responding; this was designated as the large-magnitude reinforcer. We also selected a medium magnitude that was larger than the small magnitude but did not result in decreased responding.

Contingent reinforcement (CR). The purposes of this condition were (a) to compare the effects of differing reinforcer magnitudes during a CR condition and (b) to determine whether a magnitude that did not suppress responding during brief (10-min) sessions would have a different effect during longer (30-min) sessions. The small-, medium-, and large-magnitude reinforcers identified during the CR probes were delivered according to VR 3 schedules and were alternated across sessions. The schedule of reinforcer delivery was paused during reinforcer access time (i.e., responses exhibited during reinforcer access time did not result in reinforcer delivery and were not blocked or prevented). Anecdotally, little or no responding was observed during reinforcer access time. Small- and large-magnitude sessions were 10 min in duration, whereas medium-magnitude sessions were extended to 30 min (exclusive of reinforcer consumption time). Responding during the first 10 min of the medium-magnitude sessions was compared to that observed during the small- and large-magnitude sessions to examine the effects of magnitude defined as "amount of reinforcement per delivery." Responding during the first 10 min of the medium-magnitude sessions also was compared to that observed during the entire 30-min session to examine the effects of magnitude defined as "total amount of reinforcement during the session."

Noncontingent reinforcement (NCR). The purpose of this condition was to compare the effects of NCR with those observed during the previous CR condition, as well as to examine the influence of reinforcer magnitude. Small-, medium-, and large-magnitude reinforcers were delivered according to FT schedules during 10-min sessions (medium-magnitude sessions also were extended to 30

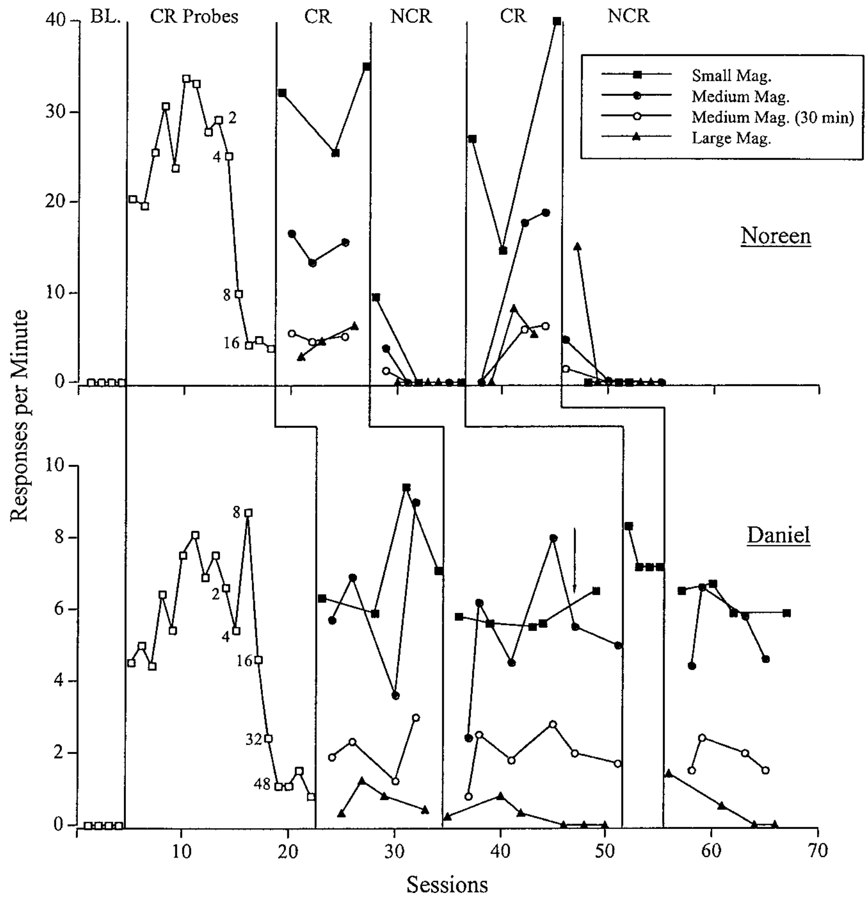

Figure 2. Responses per minute exhibited by Noreen and Daniel during no-reinforcement (baseline), contingent reinforcement probe (CR probe), contingent reinforcement (CR), and noncontingent reinforcement (NCR) conditions. The arrow indicates the point at which the same FT 24-s schedule was used for all of Daniel's NCR sessions (see text for details).

min, as in the CR condition). The FT schedule for a given reinforcer magnitude was matched to the mean rate of reinforcer delivery during VR 3 sessions from the CR condition for that same magnitude. For example, because Daniel's rate of reinforcement was 1.9 per minute (a reinforcer was delivered every 31 s) during the medium-magnitude CR condition, his schedule during the medium-magnitude NCR condition was FT 31 s. Similarly, because Daniel's rate of reinforcement during the large-magnitude CR condition was 0.25 per minute (240 s), an FT 240-s schedule was used during his large-magnitude NCR condition.

Results and Discussion

Figure 2 shows Noreen's and Daniel's rates of signing across baseline, CR probes, CR, and NCR conditions. Because of differences in the schedules used during various conditions, participants' results are presented separately.

Noreen. Noreen did not exhibit any signing during baseline. During the CR probes, her signing increased to a rate of 29.7 responses per minute during VR 3 sessions when one piece of Frito was delivered. Her responding was maintained when the reinforcer magnitude was increased to two and then four Fritos, and decreased when magnitude was increased to eight Fritos but not to below 70% of that observed during her initial VR 3 sessions. When reinforcer magnitude was increased to 16, Noreen's signing decreased below criterion for three consecutive sessions. Based on these preliminary data, 16 pieces of Frito were selected as the large-magnitude reinforcer, and four pieces were selected as the medium-magnitude reinforcer (it was the largest magnitude that did not result in a decrease in responding). During the first CR condition, Noreen exhibited high response rates (30.9 responses per minute) during small-magnitude sessions, moderate response rates (15.2) during medium-magnitude sessions, and low response rates (4.6) during large-magnitude sessions. When the medium-magnitude sessions were extended from 10 min to 30 min, her response rates decreased greatly (5.1 responses per minute) and were similar to those observed during the large-magnitude sessions. During the first NCR condition, small-, medium-, and large-magnitude reinforcers were delivered according to FT 6-s, 12-s, and 39-s schedules, respectively. Noreen exhibited low rates of signing during the first three sessions (one session of small, medium, and medium [30 min]); thereafter, she ceased responding. When the CR condition was reinstated, Noreen's responding recovered immediately during small-magnitude sessions (27.4 responses per minute) but was initially low during other sessions. Her responding eventually recovered and was maintained at rates similar to those in the previous CR condition (12.2 during medium-magnitude sessions, 4.5 during large-magnitude sessions, and 4.1 during the medium-magnitude [30-min] sessions). During the second NCR condition, Noreen again exhibited some responding during the first three sessions but stopped completely thereafter.

Daniel. Daniel never signed during baseline. During the CR probes, his signing increased to 7.1 responses per minute. When reinforcer magnitude was increased to 2, 4, 8, 16, and 32 pieces of Fritos, Daniel's signing did not decrease to below 70% of his response rate during sessions in which one Frito was delivered. However, because his responding almost met this criterion when 32 reinforcers were delivered, we elected to increase magnitude subsequently by a factor of 1.5 instead of 2. When reinforcer magnitude was increased to 48, Daniel's rate of signing decreased below 2.1. Based on this assessment, 48 pieces of Fritos were selected as the large-magnitude reinforcer, and eight pieces were selected as the medium-magnitude reinforcer. During the CR condition, Daniel exhibited similar rates of responding during small- and medium-magnitude sessions (7.2 and 6.3, respectively). He exhibited lower response rates during medium-magnitude sessions when session length was extended from 10 min to 30 min (2.1) and during large-magnitude sessions (0.7). During the first 12 sessions of the initial NCR condition, small-, medium-, and large-magnitude reinforcers were delivered according to FT 24-s, 31-s, and 240-s schedules, respectively, which were matched to reinforcement rates during the CR condition. During the latter part of the initial NCR condition (see arrow on graph) and during the entire second NCR condition, the same FT 24-s schedule (used initially only for small-magnitude sessions) was used for all three magnitudes. We equated the FT schedule across all NCR magnitudes to ensure that observed differences in response rates were not merely a function of differences in rates of reinforcement. Daniel's rates of signing during the first NCR condition were similar to those observed during the first CR condition for corresponding reinforcer magnitudes. He exhibited high response rates during small- and medium-magnitude sessions (5.8 and 5.3, respectively), lower rates during the medium-magnitude (30-min) sessions (1.9), and the lowest rates during large-magnitude sessions (0.2). When the CR condition was reinstated, only small-magnitude sessions were conducted (because of the consistency in results observed during previous CR conditions for both Daniel and Noreen), and Daniel's signing occurred at rates similar to those observed during his first CR condition (7.5). During Daniel's second exposure to NCR, reinforcers were delivered on an FT 26-s schedule (matched to the small-magnitude reinforcement rate during his second exposure to CR). Daniel again exhibited high rates of signing during small- and medium-magnitude sessions (6.3 and 5.4, respectively), lower rates during the medium-magnitude (30-min) sessions (1.9), and the lowest rates during large-magnitude sessions (0.5).

When reinforcer magnitudes were selected on the basis of their effects on behavior (CR probes), magnitude influenced responding even when session time was adjusted to account for reinforcer consumption. During the CR conditions, both participants exhibited high rates of responding during small-magnitude sessions but low rates of responding during large-magnitude sessions. Results obtained during the small- and medium-magnitude conditions were somewhat similar when sessions were 10 min in duration (although response rates were lower during medium-magnitude sessions relative to small-magnitude sessions for Noreen); however, response rates during the medium-magnitude condition resembled more closely those observed during the large-magnitude condition when the medium-magnitude sessions were extended from 10 min to 30 min. Thus, reinforcer magnitude influenced responding but also depended on the total amount of reinforcement consumed during a session.

When reinforcer magnitude was varied during the NCR condition, different results were obtained for Noreen and Daniel. Although Noreen's data did not reveal any sensitivity to reinforcer magnitude, they were different than those presented by Ecott et al. (1999), whose participants continued to respond during all NCR conditions. By contrast, Noreen consistently ceased responding during six NCR conditions (three reinforcer magnitudes, each replicated). Daniel's pattern of responding during the NCR condition closely resembled that observed during the CR condition and revealed a very clear effect for reinforcer magnitude. These results were similar to those reported by Carr et al. (1998).

GENERAL DISCUSSION

Previous research has produced mixed findings on the extent to which reinforcer magnitude influences responding during NCR (Carr et al., 1998; Ecott et al., 1999). In the present study, we examined several characteristics of reinforcer magnitude with additional controls and found that larger magnitudes of reinforcement (a) extend reinforcer consumption time, which may suppress overall response rates in a session (Study 1); (b) can reduce response rates even when session time is corrected to account for differing durations of consumption (Study 2); and (c) can influence behavior as a function of either amount of reinforcer consumed per delivery or amount consumed across a session (Study 2). In addition, the latter effects were observed across two types of schedules—CR and NCR.

In Study 1, a larger magnitude of NCR resulted in larger decreases in responding than did a smaller magnitude, but only when time spent consuming reinforcers was counted as running time (i.e., it was included in the time used to calculate response rate). However, when reinforcer consumption time was subtracted from total session time, response rates under medium-magnitude NCR were as high as (Calvin) or higher than (Brett) they were under small-magnitude NCR. Thus, Calvin's and Brett's lower response rates under medium-magnitude NCR resulted from the fact that they spent more time consuming reinforcers. These findings illustrate the importance of taking reinforcer consumption time into consideration when comparing response rates across conditions in which reinforcer magnitude (and perhaps rate) differs noticeably. The extent to which reinforcer access time influences response rate is not always clear even in basic research (Doughty & Richards, 2002; Shahan, 2002), although it is assumed that correction procedures such as those described by Lattal (1991) and Mazur (1983) are used.

In Study 2, we attempted to resolve conflicting findings reported by Carr et al. (1998) and Ecott et al. (1999). Carr et al. observed differences in response rate under NCR as a function of reinforcer magnitude, whereas Ecott et al. did not. We first defined magnitude empirically by observing response rates during a series of CR probes, selecting reinforcer magnitudes that seemed to affect responding, and verifying the influence of reinforcer magnitude during a subsequent CR condition. We then implemented NCR using reinforcer magnitudes that did and did not result in response suppression during the CR condition. Results for 1 participant (Noreen) showed response suppression across all NCR magnitudes, indicating that the same magnitudes that maintained responding during CR (small magnitude and 10-min medium magnitude) did not maintain responding during NCR. Daniel's results showed decreases in responding during NCR only with magnitudes that had produced the same effect during CR (large magnitude and 30-min medium magnitude). Thus, although both participants appeared to show satiation to larger magnitudes of reinforcement during CR, they responded differently during NCR. Noreen's results suggested that satiation had little influence over her behavior during NCR because even small magnitudes of reinforcement, when delivered noncontingently, produced decreases in responding. By contrast, Daniel's results seemed most consistent with a satiation effect. These interpretations are strengthened in light of results obtained during the CR condition and illustrate the importance of defining "magnitude of reinforcement" functionally as well as quantitatively.

Results of Study 2 also indicated that reinforcer magnitude can influence behavior in at least two different ways. We altered the number of reinforcers delivered to participants by (a) varying the amount of food per reinforcer delivery and (b) extending session length, and these manipulations had similar effects (during CR for Noreen and during CR and NCR for Daniel). That is, when a larger number of reinforcers was presented during each delivery, decreases were observed relative to conditions in which a small number of reinforcers was presented per delivery (large vs. small magnitude). In addition, when a constant number of reinforcers was presented per delivery (medium magnitude), differences in responding during the first 10 min of a session versus the entire 30 min resembled differences observed when large and small reinforcer magnitudes were delivered.

The results obtained in this study have clinical relevance because NCR has become an increasingly common treatment for many forms of problem behavior. The present results (combined with those of Carr et al., 1998) suggest that magnitude of reinforcement may be a determining factor of the therapeutic effects of NCR. That is, NCR may not reduce problem behavior if insufficient reinforcement is delivered, and the quantity of reinforcers needed to produce therapeutic effects may far exceed that to which an individual was exposed prior to treatment (i.e., during baseline). However, it is important to replicate these findings in a clinical context to determine whether magnitude influences are observed with other response topographies.

Another finding that may be relevant to the clinical use of NCR was the fact that behavioral maintenance was observed under some NCR conditions in both Study 1 (Calvin and Brett) and Study 2 (Daniel). Two factors may have accounted for this finding. First, we used an intermittent reinforcement schedule during baseline to increase resistance to extinction so magnitude effects could be observed. This practice was different from that followed in clinical research, in which problem behavior is reinforced continuously during baseline. Second, it is possible that response maintenance during NCR may have been a function of adventitious reinforcement (unprogrammed temporal contiguity between responding and reinforcer delivery). However, the extent to which either of these variables affected performance is unknown, and additional research is needed to examine these potential influences explicitly.

The present study focused on reinforcer magnitude in the context of contingent versus noncontingent reinforcement. Reinforcer magnitude also may influence behavior during extinction. For example, Lerman, Kelley, Vorndran, Kuhn, and LaRue (2002) recently examined the effects of reinforcer magnitude on responding during a subsequent extinction condition. During baseline, participants received either 20-s or 60-s access to the reinforcer that maintained their problem behavior. Results showed minimal differences in resistance to extinction following exposure to the two reinforcer magnitudes. One explanation for these results may have been the fact that differences in responding were not observed under the two reinforcer magnitudes during the CR condition. Our results showed that, when magnitude effects were not observed during CR, they also were not observed during NCR. It is unclear whether a similar finding would be obtained when extinction effects are examined, but future studies could manipulate magnitude until functional differences in responding are observed during CR prior to implementing extinction. Another potential explanation for why differences in resistance to extinction were not obtained was that Lerman et al. used tangible items or escape, rather than food items, as a reinforcer. It may be more difficult to obtain within-session satiation effects when using nonfood items.

Contemporary research in applied behavior analysis places great emphasis on the identification of reinforcement contingencies that maintain problem behavior as a basis for developing intervention strategies. Perhaps equally important are a variety of ways in which quantitative and qualitative characteristics of reinforcers can differ both prior to and during treatment. Although the ultimate test of whether these characteristics influence treatment effects must be conducted in a clinical context, nonclinical studies such as those described here may facilitate identification of promising variables that are worth exploring under more naturalistic conditions.

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STUDY QUESTIONS

1. Describe two limitations of recent studies on reinforcer magnitude that were addressed in the current study.

2. Describe the three NCR conditions that were compared in Study 1.

3. Briefly summarize the results of Study 1.

4. How were the NCR schedules determined in Studies 1 and 2?

5. Describe the way in which reinforcer magnitude was operationalized in Study 2.

6. Why was the medium-magnitude (30-min) NCR condition included in Study 2?

7. Summarize the results of Study 2.

8. What are the implications of the present results for the use of NCR as a behavior-reduction procedure?

Questions prepared by Leah Koehler and Stephen North, University of Florida